Inorganic Pharmaceutical Chemistry

3rd Class 1st Semester

Reference text:-

1- Inorganic Medicinal and Pharmaceutical Chemistry

by Block ,Roche Soine and Wilson

2- Textbook of Organic Medicinal and Fharmaceutical Chemistry by Wilson and Gisvold

1- Atomic Structure 3/11/2011

The sub-atomic particles

Protons, neutrons and electrons.

	relative mass	relative charge
proton	1	+1
neutron	1	0
electron	1/1836	-1

The behavior of protons, neutrons and electrons in electric fields

What happens if a beam of each of these particles is passed between two electrically charged plates - one positive and one negative? Opposites will attract.

Protons are positively charged and so would be deflected on a curving path towards the negative plate.

Electrons are negatively charged and so would be deflected on a curving path towards the positive plate.

Neutrons don't have a charge, and so would continue on in a straight line.

Exactly what happens depends on whether the beams of particles enter the electric field with the various particles having the same speeds or the same energies

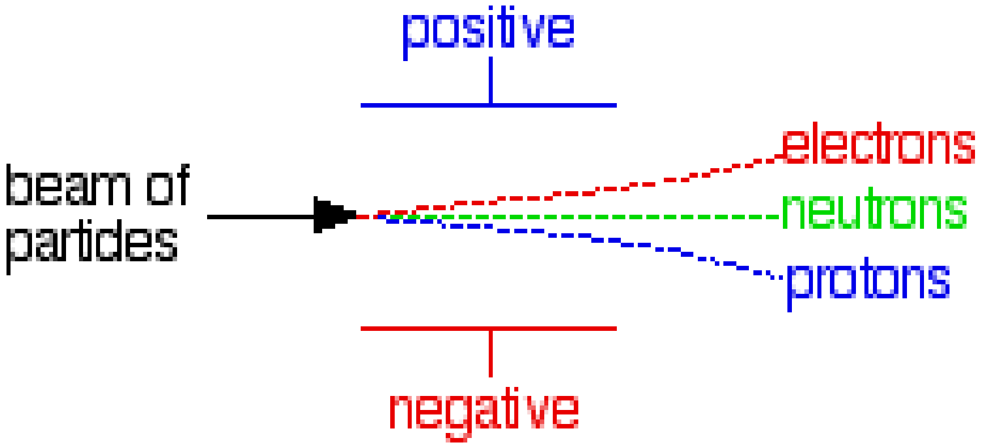
If the particles have the same energy

If beams of the three sorts of particles, *all with the same energy*, are passed between two electrically charged plates:

- Protons are deflected on a curved path towards the negative plate.
- Electrons are deflected on a curved path towards the positive plate.

  The amount of deflection is exactly the same in the electron beam as the proton beam if the energies are the same - but, of course, it is in the opposite direction.

- Neutrons continue in a straight line.



If the electric field was strong enough, then the electron and proton beams might curve enough to hit their respective plates.

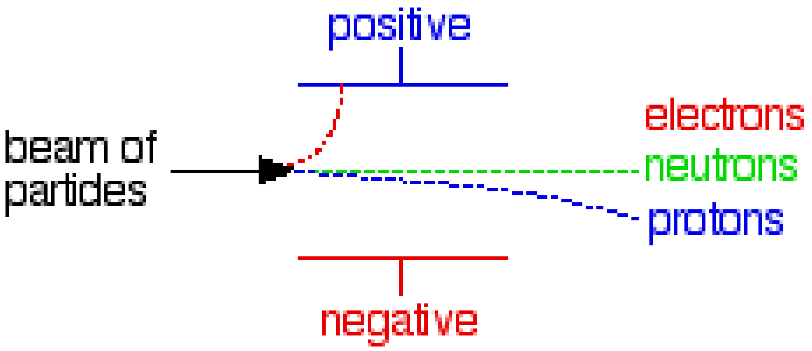
If the particles have the same speeds

If beams of the three sorts of particles, *all with the same speed*, are passed between two electrically charged plates:

- Protons are deflected on a curved path towards the negative plate.
- Electrons are deflected on a curved path towards the positive plate.

  If the electrons and protons are travelling with the same speed, then the lighter electrons are deflected far more strongly than the heavier protons.

- Neutrons continue in a straight line.



The nucleus

The nucleus is at the centre of the atom and contains the protons and neutrons. Protons and neutrons are collectively known as ***nucleons.***

Virtually all the mass of the atom is concentrated in the nucleus, because the electrons weigh so little.

Working out the numbers of protons and neutrons

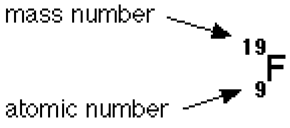
No of protons = ATOMIC NUMBER of the atom

The atomic number is also given the more descriptive name of ***proton number.***

No of protons + no of neutrons = MASS NUMBER of the atom

The mass number is also called the ***nucleon number.***

This information can be given simply in the form:



How many protons and neutrons has this atom got?

The atomic number counts the number of protons (9); the mass number counts protons + neutrons (19). If there are 9 protons, there must be 10 neutrons for the total to add up to 19.

The atomic number is tied to the position of the element in the Periodic Table and therefore the number of protons defines what sort of element you are talking about. So if an atom has 8 protons (atomic number = 8), it must be oxygen. If an atom has 12 protons (atomic number = 12), it must be magnesium.

Similarly, every chlorine atom (atomic number = 17) has 17 protons; every uranium atom (atomic number = 92) has 92 protons.

Isotopes

The number of neutrons in an atom can vary within small limits. For example, there are three kinds of carbon atom ^{12}C, ^{13}C and ^{14}C. They all have the same number of protons, but the number of neutrons varies.

	protons	neutrons	mass number
carbon-12	6	6	12
carbon-13	6	7	13
carbon-14	6	8	14

These different atoms of carbon are called ***isotopes***. The fact that they have varying numbers of neutrons makes no difference whatsoever to the chemical reactions of the carbon.

Isotopes are atoms which have the same atomic number but different mass numbers. They have the same number of protons but different numbers of neutrons.

The electrons

Working out the number of electrons

Atoms are electrically neutral, and the positiveness of the protons is balanced by the negativeness of the electrons. It follows that in a neutral atom:

no of electrons = no of protons

So, if an oxygen atom (atomic number = 8) has 8 protons, it must also have 8 electrons; if a chlorine atom (atomic number = 17) has 17 protons, it must also have 17 electrons.

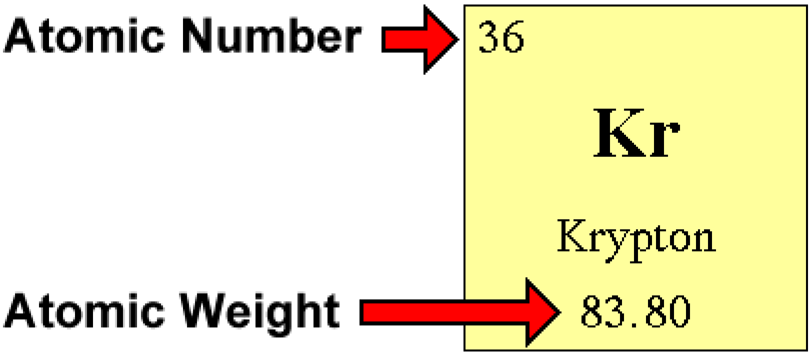
How many protons, electrons and neutrons are in an atom of krypton, carbon, oxygen, neon, silver, gold, etc...?

To find the number of protons, electrons and neutrons in an atom, just follow these easy steps:

Step 1 - Gather Information

The first thing you will need to do is find some information about your element. Go to the Periodic Table of Elements and click on your element. If it makes things easier, you can select your element from an alphabetical listing.

Use the Table of Elements to find your element's atomic number and atomic weight. The atomic number is the number located in the upper left corner and the atomic weight is the number located on the bottom, as in this example for krypton:



Step 2 - The Number of Protons is...

The **atomic number** is the number of protons in an atom of an element. In our example, krypton's atomic number is 36. This tells us that an atom of krypton has 36 protons in its nucleus.

The interesting thing here is that **every** atom of krypton contains 36 protons. If an atom doesn't have 36 protons, it can't be an atom of krypton. Adding or removing protons from the nucleus of an atom creates a different element. For example, removing one proton from an atom of krypton creates an atom of bromine.

Step 3 - The Number of Electrons is...

By definition, atoms have no overall electrical charge. That means that there must be a balance between the positively charged protons and the negatively charged electrons. Atoms must have **equal numbers of protons and electrons**. In our example, an atom of krypton must contain 36 electrons since it contains 36 protons.

Electrons are arranged around atoms in a special way. If you need to know how the electrons are arranged around an atom, take a look at the 'How do I read an electron configuration table?' page.

An atom can gain or lose electrons, becoming what is known as an **ion**. An ion is nothing more than an electrically charged atom. Adding or removing electrons from an atom does not change which element it is, just its net charge.

For example, removing an electron from an atom of krypton forms a krypton ion, which is usually written as Kr^+. The plus sign means that this is a positively charged ion. It is positively charged because a negatively charged electron was removed from the atom. The 35 remaining electrons were outnumbered by the 36 positively charged protons, resulting in a charge of +1.

Step 4 - The Number of Neutrons is...

The **atomic weight** is basically a measurement of the **total number of particles in an atom's nucleus**. In reality, it isn't that clean cut. The atomic weight is actually a weighted average of all of the naturally occurring isotopes of an element relative to the mass of carbon-12. Didn't understand that? Doesn't matter. All you really need to find is something called the **mass number**. Unfortunately, the mass number isn't listed on the Table of Elements. Happily, to find the mass number, all you need to do is**round the atomic weight to the nearest whole number**. In our example, krypton's mass number is 84 since its atomic weight, 83.80, rounds up to 84.

The mass number is a count of the number of particles in an atom's nucleus. Remember that the nucleus is made up of protons and neutrons. So, if we want, we can write:

Mass Number = (Number of Protons) + (Number of Neutrons)

For krypton, this equation becomes:

84 = (Number of Protons) + (Number of Neutrons)

If we only knew how many protons krypton has, we could figure out how many neutrons it has. Wait a minute... We **do** know how many protons krypton has! We did that back in **Step 2**! The **atomic number** (36) is the number of protons in krypton. Putting this into the equation, we get:

84 = 36 + (Number of Neutrons)

What number added to 36 makes 84? Hopefully, you said 48. That is the number of neutrons in an atom of krypton.

The interesting thing here is that adding or removing neutrons from an atom does not create a different element. Rather, it creates a heavier or lighter version of that element. These different versions are called isotopes and most elements are actually a mixture of different isotopes.

If you could grab atoms of krypton and count the number of neutrons each one had, you would find that most would have 48, others would have 47, some would have 50, some others would have 46, a few would have 44 and a very few would have 42. You would count different numbers of neutrons because krypton is a mixture of six isotopes.

In Summary...

For any element:

Number of Protons = Atomic Number

Number of Electrons = Number of Protons = Atomic Number

Number of Neutrons = Mass Number - Atomic Number

For krypton:

Number of Protons = Atomic Number = 36

Number of Electrons = Number of Protons = Atomic Number = 36

Number of Neutrons = Mass Number - Atomic

Number = 84 - 36 = 48

The arrangement of the electrons

The electrons are found at considerable distances from the nucleus in a series of levels called energy levels. Each energy level can only hold a certain number of electrons. The first level (nearest the nucleus) will only hold 2 electrons, the second holds 8, and the third also seems to be full when it has 8 electrons. These levels can be thought of as getting progressively further from the nucleus. Electrons will always go into the lowest possible energy level (nearest the nucleus) - provided there is space.

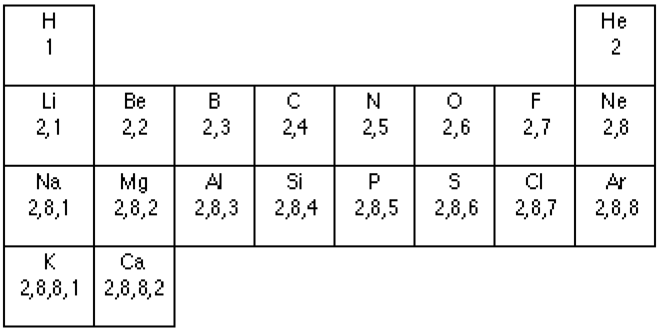
To work out the electronic arrangement of an atom

- Look up the atomic number in the Periodic Table - making sure that you choose the right number if two numbers are given. The atomic number will always be the smaller one.
- This tells you the number of protons, and hence the number of electrons.
- Arrange the electrons in levels, always filling up an inner level before you go to an outer one.

e.g. to find the electronic arrangement in chlorine

- The Periodic Table gives you the atomic number of 17.
- Therefore there are 17 protons and 17 electrons.
- The arrangement of the electrons will be 2, 8, 7 (i.e. 2 in the first level, 8 in the second, and 7 in the third).

The electronic arrangements of the first 20 elements



H 1							He 2
Li 2,1	Be 2,2	B 2,3	C 2,4	N 2,5	O 2,6	F 2,7	Ne 2,8
Na 2,8,1	Mg 2,8,2	Al 2,8,3	Si 2,8,4	P 2,8,5	S 2,8,6	Cl 2,8,7	Ar 2,8,8
K 2,8,8,1	Ca 2,8,8,2						

After this the pattern alters as you enter the transition series in the Periodic Table.

Two important generalisations

If you look at the patterns in this table:

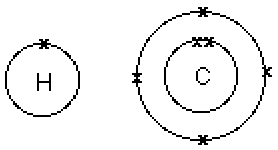
- The number of electrons in the outer level is the same as the group number. (Except with helium which has only 2 electrons. The noble gases are also usually called group 0 - not group 8.) This pattern extends throughout the Periodic Table for the main groups (i.e. not including the transition elements).

  So if you know that barium is in group 2, it has 2 electrons in its outer level; iodine (group 7) has 7 electrons in its outer level; lead (group 4) has 4 electrons in its outer level.

- Noble gases have full outer levels. This generalisation will need modifying for A'level purposes.

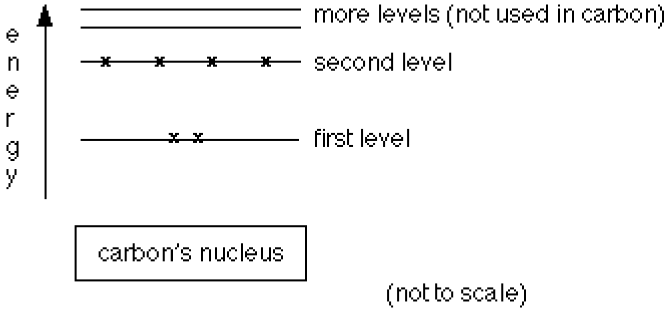
Dots-and-crosses diagrams

In any introductory chemistry course you will have come across the electronic structures of hydrogen and carbon, for example, drawn as:



The circles show energy levels - representing increasing distances from the nucleus. You could straighten the circles out and draw the electronic structure as a simple energy diagram.

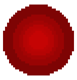
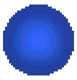
Carbon, for example, would look like this:



Thinking of the arrangement of the electrons in this way makes a useful bridge to the A'level view.

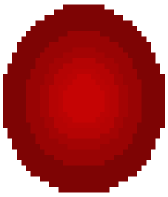
Atomic Structure

that atoms were particles of elements, substances that could not be broken down. In examining atomic structure though, we have to clarify this statement. An atom cannot be broken down further without changing the chemical nature of the substance. For example, if you have 1 ton, 1 gram or 1 atom of oxygen, all of these units have the same properties. We can break down the atom of oxygen into smaller particles, however, when we do the atom looses its chemical-properties.

Atoms are made up of 3 types of particles **electrons** , **protons**  and **neutrons** . These particles have different properties. **Electrons** are tiny, very light particles that have a negative electrical charge (-). **Protons** are much larger and heavier than electrons and have the opposite charge, protons have a positive charge. **Neutrons** are large and heavy like protons, however neutrons have no electrical charge. Each atom is made up of a combination of these particles. Let's look at one type of atom:

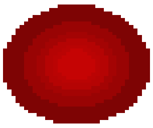
The atom above, made up of one proton and one electron, is called hydrogen (the abbreviation for hydrogen is H). The proton and electron stay together because just like two magnets, the opposite electrical charges attract each other. What keeps the two from crashing into each other? The particles in an atom are not still. The electron is constantly spinning around the center of the atom (called the nucleus). The centrigugal force of the spinning electron keeps the two particles from coming into contact with each other much as the earth's rotation keeps it from plunging into the sun. Taking this into consideration, an atom of hydrogen would look like this:

A Hydrogen Atom



Keep in mind that atoms are extremely small. One hydrogen atom, for example, is approximately 5 x 10^{-8} mm in diameter. To put that in perspective, this dash - is approximately 1 mm in length, therefore it would take almost 20 million hydrogen atoms to make a line as long as the dash. In the sub-atomic world, things often behave a bit strangely. First of all, the electron actually spins very far from the nucleus. If we were to draw the hydrogen atom above to scale, so that the proton were the size depicted above, the electron would actually be spinning approximately 0.5 km (or about a quarter of a mile) away from the nucleus. In other words, if the proton was the size depicted above, the whole atom would be about the size of Giants Stadium. Another peculiarity of this tiny world is the particles themselves. Protons and neutrons behave like small particles, sort of like tiny billiard balls. The electron however, has some of the properties of a wave. In other words, the electron is more similar to a beam of light than it is to a billiard ball. Thus to represent it as a small particle spinning around a nucleus is slightly misleading. In actuality, the electron is a wave that surrounds the nucleus of an atom like a cloud. While this is difficult to imagine, the figure below may help you picture what this might look like:

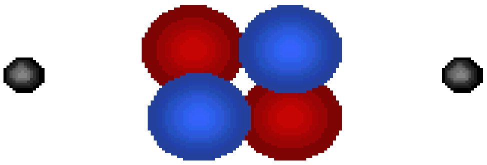
Hydrogen: a proton surrounded by an electron cloud



While you should keep in mind that electrons actually form clouds around their nucleii, we will continue to represent the electron as a spinning particle to keep things simple.

In an electrically neutral atom, the positively charged protons are always balanced by an equal number of negatively charged electrons. As we have seen, hydrogen is the simplest atom with only one proton and one electron. Helium is the 2nd simplest atom. It has two protons in its nucleus and two electrons spinning around the nucleus. With helium though, we have to introduce another particle. Because the 2 protons in the nucleus have the same charge on them, they would tend to repel each other, and the nucleus would fall apart. To keep the nucleus from pushing apart, helium has two neutrons in its nucleus. Neutrons have no electrical charge on them and act as a sort of nuclear glue, holding the protons, and thus the nucleus, together.

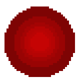
A Helium Atom



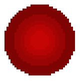
As you can see, helium is larger than hydrogen. As you add electrons, protons and neutrons, the size of the atom increases. We can measure an atom's size in two ways: using the atomic number (Z) or using the atomic mass (A, also known as the mass number). The atomic number describes the number of protons in an atom. For hydrogen the atomic number, Z, is equal to 1. For helium Z = 2. Since the number of protons equals the number of electrons in the neutral atom, Z also tells you the number of electrons in the atom. The atomic mass tells you the number of protons plus neutrons in an atom. Therefore, the atomic mass, A, of hydrogen is 1. For helium A = 4.

Ions and Isotopes

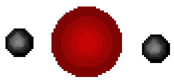
So far we have only talked about electrically neutral atoms, atoms with no positive or negative charge on them. Atoms, however, can have electrical charges. Some atoms can either gain or lose electrons (the number of protons never changes in an atom). If an atom gains electrons, the atom becomes negatively charged. If the atom loses electrons, the atom becomes positively charged (because the number of positively charged protons will exceed the number of electrons). An atom that carries an electrical charge is called an **ion**. Listed below are three forms of hydrogen; 2 ions and the electrically neutral form.



H^+ : a positively charged hydrogen **ion**



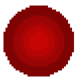
H : the hydrogen atom



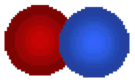
H^- : a negatively charged hydrogen **ion**

Neither the number of protons nor neutrons changes in any of these ions, therefore both the atomic number and the atomic mass remain the same. While the number of protons for a given atom never changes, the number of neutrons can change. Two atoms with different numbers of neutrons are called **isotopes**. For example, an isotope of hydrogen exists in which the atom contains 1 neutron (commonly called deuterium). Since the atomic mass is the number of protons plus neutrons, two isotopes of an element will have different atomic masses (however the atomic number, Z, will remain the same).

Two **isotopes** of hydrogen



Hydrogen
Atomic Mass = 1
Atomic Number = 1



Deuterium
Atomic Mass = 2
Atomic Number = 1